The Use and Impact of Problem-Based Instruction on the Academic Performance of High School Students

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Abstract. This quasi-experimental research aims to know the effect of the Problem-Based Learning (PBL) model on the learning outcomes of Class XI Senior High School students at Bulukumba Regency on the subject matter of hydrocarbon compounds. A posttest-only control group design was utilized for the research that was carried out. In this investigation, the PBL model is the independent variable, and the students' learning outcomes concerning hydrocarbon compounds are the dependent variable. The population in this study were students of class XI Senior High School at Bulukumba Regency, consisting of four classes. Sampling was done by random sampling. The experimental group is Class XI-4, and the control group is Class XI-3. This study uses descriptive analysis and inferential analysis. According to the descriptive study's findings, the experimental group's average learning outcomes were 73 points higher than those of the control group, which were found to be 72.40. The inferential statistical analysis on student education outcomes revealed that the experimental and control groups' data belonging to homogeneous populations were not normally distributed. So, the hypothesis test was a non-parametric statistical test, Mann-Whitney, with α 0.05. The test results obtained Z-count > Z-table (6.98 > 1.64). Thus, it can be concluded that the PBL model affects students' learning outcomes in class XI Senior High School at Bulukumba Regency on the subject matter of hydrocarbon compounds.

Keywords: Chemistry Teachers · Learning Process · Learning Model · Problem-based Learning

1 Introduction

The model of education known as problem-based learning presents students with a challenge based on the real world. Students solve problems in groups to increase understanding and build a frame of mind compared to just listening to or receiving material from the teacher [1]. Solving problems in the material of hydrocarbon compounds requires students to be more creative and innovative. For students to have better learning outcomes in the chemistry material being taught, problem-based learning requires them to take an active part in learning activities that are not only teacher-centered [2].

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Student activity during the learning process shows that students are less interested, where students only learn if the learning process in class takes place. Students only rely on information from the teacher and then record it linearly and memorize it according to what is written in the book [3]. In addition, during the learning process, several students discussed it with their friends. Students only listen to the teacher explain the learning process, making them bored and sleepy [4]. The learning system in the classroom also tends to be individualistic, with interactions that occur only between teachers and students, not between students [5, 6]. Therefore, choosing a suitable learning model is necessary to overcome this problem. One learning model that activates students is problem-based.

The results of observations and interviews were conducted with chemistry teachers at a Senior High School at Bulukumba Regency, one of the schools in Indonesia that has implemented the 2013 curriculum. In practice, chemistry teachers still use conventional learning models in the learning process in class. Learning begins with explaining the material directly from the teacher; then, students are allowed to ask questions about things they have not understood, and ends with giving exercises and assignments.

Learning is still based on the teacher, where students follow the lessons in a class by listening to lectures and working on questions given by the teacher [7]. This situation causes chemistry learning to take place monotonously or less varied, causing chemistry learning outcomes not to be adequately achieved. This impacts the average learning outcomes of students who are low and do not meet the completeness standard set by the school. Based on the background above, the authors are interested in conducting related research, "*The Effect of the Problem-Based Learning Model on Learning Outcomes*."

2 Method

In the odd semester of the academic year 2021–2022, a senior high school in Bulukumba Regency conducted a quasi-experimental study on this investigation's subject. Class XI, which had four classes, was the entire population in this study for the academic year 2021–2022. The sample used in this study consisted of an experimental group and a control group. The group that was participating in the experiment received care.

The experimental group in this study received a particular treatment, the impact of which on the observed variable was then to be assessed. On the other hand, the control group was used to compare how the effects of the treatment- and control-group recipients differed. At a senior high school in Bulukumba Regency, the research sought to evaluate the impact of a particular treatment on class XI students. The researcher measured the treatment's impact on the observed variable using a quasi-experimental design while controlling for some variables that might impact the study's findings.

Problem-based learning and traditional learning models are the independent variables in this study, and the dependent variable is the student's learning outcomes in the hydrocarbon compounds subject. The learning outcomes test instrument, which has undergone validity testing using content by the validator, is used in this study [8, 9]. The Mann-Whitney Test, a non-parametric statistical test, was used in this study.

The data are arranged in descending order for the Mann-Whitney test. The value of U is then calculated to ascertain how different the two groups are. When determining whether there is a significant difference between the two groups, the null hypothesis (H0), which states that there is none, is tested using this U value. If the calculated U value exceeds the threshold value, the null hypothesis is disproved, and it is concluded that there is a significant difference between the two groups regarding student learning outcomes.

3 Results and Discussion

3.1 Descriptive Statistical Analysis

The data in the Table shows that the learning outcomes of students in the experimental group are slightly higher than that of the control group. The descriptive statistical analysis results in Table 1 show a difference in the average learning outcomes of the experimental and control groups. The average value obtained by the experimental group using the PBL model was 73, while the control group was taught using a conventional learning model of 72.4.

This shows that most students in the experimental group obtained higher learning outcomes than the control group. Based on the stages of the Problem-Based Learning (PBL) model, the stages that can influence student learning outcomes are the problem-solving stage, where at the problem-solving stage students discuss with each other to find answers to problems independently. At this stage, the material that students have not understood can be known was not known before. Students will increasingly understand the concept more deeply, which can influence learning outcomes.

Based on Table 2, which presents the percentage of completeness for each class, the number of students who passed in the experimental class, as many as 21 people had a percentage of 63.64% higher than the number of students who passed in the control class, namely 18 people with a percentage of 54.54%. This indicated that the achievement of student learning outcomes using Problem-Based Learning (PBL) models is higher than students who use conventional learning models. This is supported by the research conducted by [10], which reports that the problem-based learning model can improve students' ability to solve chemistry problems and can also improve students' critical thinking skills. Furthermore, [11] reported that applying the Problem-Based Learning

Table 1. Descriptive Statistical Analysis of Student Learning Outcomes

Statistic	Experiments Group	Control Group
Number of samples	33.00	33.00
Average score	73.00	72.40
Median	75.16	76.41
Modus	76.42	79.27
Variance	146	137.60
Deviation Standard	12.10	11.70

Table 2. Percentage of Complete Learning Outcomes (CLO) of Students

Category	CLO	Experiments Group		Control Group	
		F	%	F	%
Complete	≥75	21	63.64	18	54.54
Not Complete	<75	12	36.36	15	45.46

(PBL) model strategy received a positive response from students who were taught the PBL strategy in essential chemistry for biology courses. Applying the Problem-Based Learning (PBL) model could increase the understanding of thermochemical concepts for high school students with an N-gain value of 0.80 in the high category.

The value of student learning outcomes, if classified based on the achievement of each indicator, then the average percentage of achievement for each indicator for the

Table 3. Student Learning Outcomes Achievement Indicators

Indicators	Experiments Group			Control Group		
	Freq	%	Category	Freq	%	Category
1. Describe the peculiarities of carbon atoms in carbon compounds	27	81.81	Complete	26	78.79	Complete
2. Distinguishing the type of C atom based on the number of bonded C atoms of the carbon chain	25	75.76	Complete	25	75.76	Complete
3. Classify hydrocarbon compounds based on bond saturation	9	27.27	Not Complete	12	36.36	Not Complete
4. Name the structure of Alkanes, Alkenes, and Alkynes based on IUPAC analysis	12	36.36	Not Complete	24	72.73	Not Complete
5. Analyzing the physical properties of alkanes, alkenes, and alkynes	8	24.24	Not Complete	12	36.36	Not Complete
6. Determine isomers of alkanes, alkenes, and alkynes	25	75.76	Complete	20	60.60	Not Complete
7. Analyzing reactions of hydrocarbon compounds	20	60.60	Not Complete	9	27.27	Not Complete
Average		**54.54**			**55.41**	

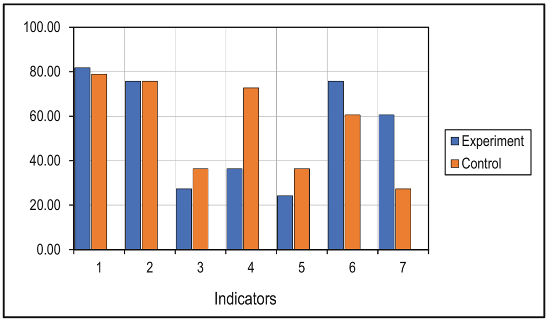

Fig. 1. Bar chart of the completeness value categorization of each indicator for the experimental and control groups

experimental and control groups, and visualization of the percentage of achievement indicators in the experimental and control group are shown in Fig. 1 and Table 3.

The descriptive statistical analysis results in Table 3 and Fig. 1 show the achievement percentage of each indicator of student learning outcomes, consisting of seven indicators of competency achievement. The material for hydrocarbon compounds is narrative. The percentage of achievement indicators of learning outcomes in the experimental group is higher than the average percentage of achievement indicators of learning outcomes in the control class. Table 3 also shows that three indicators were completed in the experimental class, namely indicators 1, 2, and 6. In contrast, in the control class, only two indicators were completed, namely indicators 1 and 2. The first indicator described the uniqueness of the carbon atoms in carbon compounds. The percentage of completeness in the experimental group was 81.81%, while the control group was 78.79%. Based on the results of the percentage of the two indicators, it shows that the first indicator in both classes is included in the complete category, and the percentage of completeness in the experimental class is higher because giving problems at the beginning of learning will provide opportunities for students to find solutions to problems independently and in groups so that students more easily understand the uniqueness of carbon atoms [12].

The second indicator is to distinguish the type of C atom based on the number of bonded C atoms from the carbon chain; the percentage of completeness in the experimental group and the control group is the same, namely 75.76%, so this second indicator is included in the complete category for both classes. Likewise with the third indicator, namely classifying hydrocarbon compounds based on bond saturation, the percentage of completeness in the experimental group was 27.27%, while the control group was 36.36%.

Based on the results of the percentage of the two indicators, it shows that the third indicator in both groups is included in the incomplete category, and the percentage of completeness in the experimental group is lower because the students in the experimental group do not understand well the solution to the problem solving obtained regarding the classification of hydrocarbon compounds based on their bond saturation.

The fourth indicator is to name the structure of Alkanes, Alkenes, and Alkynes based on IUPAC analysis. The fifth indicator analyzes the physical properties of alkanes, alkenes, and alkynes. Both of these indicators had a lower percentage of completeness in the experimental class, namely 36.36% for the fourth indicator and 24.24% for the fifth indicator, compared to the control class, namely 72.73% for the fourth indicator and 36.36% for the fifth indicator and including the incomplete category. The incompleteness of this fourth indicator is because students are still experiencing difficulties determining the main chain and its branch chains.

The sixth indicator determines isomers of alkanes, alkenes, and alkynes. The percentage of completeness in the experimental class is 75.76%. In comparison, the control class is 60.60%, in the experimental class it has a higher percentage of completeness because giving problems at the beginning of learning will provide opportunities for students to find solutions to problems independently or in groups and are included in the category complete compared to the control class which is included in the incomplete category. This is because most students in the control class do not understand the isomers of alkanes, alkenes, and alkynes.

The seventh indicator is to analyze the reaction of hydrocarbon compounds. The percentage of completeness in the experimental class was 60.60%, while the control class was 27.27%. The experimental class is higher because giving problems at the beginning of learning will allow students to find solutions to problems independently and in groups to analyze the reactions of hydrocarbon compounds quickly. Although several indicators have not reached completeness, the problem-based learning model in the experimental class can help students understand the material of hydrocarbon compounds to improve their learning outcomes [13].

3.2 Inferential Statistical Analysis

The learning outcomes of the experimental and control groups were first tested for normality and homogeneity before the hypothesis was tested. The normality test results revealed that the data are not distributed normally. The Mann-Whitney test, a non-parametric statistical test, is used in the hypothesis test. Testing one way is how hypotheses are tested. Table 4 displays the findings of the hypothesis test.

Table 4 shows that the value of Z-count = 6.98 and the value of Z-table = 1.64 at a confidence level of 0.05. Because Z-count > Z-table (6.98 > 1.64), H_0 failed. It can be concluded that the Problem-Based Learning (PBL) model influences students' learning outcomes on hydrocarbon compounds.

Based on the results of hypothesis testing is obtained Z-count > Z-table where H_1 is accepted, or H_0 is failed, which means the proposed hypothesis is accepted (Table 4). It can be concluded that using PBL models affects the learning outcomes of class students XI Senior High School at Bulukumba Regency on the subject matter of hydrocarbon compounds. This is relevant to the study's statement that the experimental group

Table 4. Results of Hypothesis Testing

Group	**Z-$_{\text{count}}$**	**Z-$_{\text{table}}$**	**Description**
Experiment	6.98	1.64	H_0 is failed
Control			

taught by the Problem-Based Learning (PBL) model had a higher influence on student learning outcomes than the control group [14, 15]. Applying the problem-based learning model in the learning process influences student learning outcomes. The effect of using Problem-Based Learning (PBL) models in improving student learning outcomes. Using problem-based learning models is an alternative for teachers to facilitate learning in the form of concepts [16]. The Problem-Based Learning (PBL) model directs students to find their concepts, ideas, and knowledge. This is also supported by [17], which states that the PBL learning strategy is a model with an investigative nuance that can also develop critical thinking skills and mastery of chemical concepts so that it influences the learning outcomes obtained by students. This study also reported that the Problem-Based Learning (PBL) model combined with Numbered Heads Together (NHT) could also increase students' learning motivation and creativity [18, 19].

4 Conclusion

In this research, the results of the Mann-Whitney test showed a significant difference in learning outcomes between the group of students who received problem-based learning (experimental group) and the group of students who received traditional learning (control group) in the hydrocarbon compounds material. Therefore, it can be concluded that the Problem-Based Learning (PBL) Model affects students' learning outcomes at Senior High School in Bulukumba Regency studying hydrocarbon compounds. Thus, the PBL model can be recommended as a better learning method for the hydrocarbon compounds material for students at Senior High School. This study's findings suggest that using the PBL model can improve students' learning outcomes in the hydrocarbon compounds material, compared to using the traditional learning model.

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